Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
Amendment of Parts 2 and 25 of the	)	
Commission's Rules to Permit Operation	)	ET Docket No. 98-206
of NGSO FSS Systems Co-Frequency with	)	RM-9147
GSO and Terrestrial Systems in the Ku-Band	)	RM-9245
and	)	
Amendment of the Commission's Rules	)	
to Authorize Subsidiary Terrestrial Use	)	
of the 12.2-12.7 GHz Band by Direct	)	
Broadcast Satellite Licensees and Their	)	
Affiliates	)	

COMMENTS OF SKYBRIDGE

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March 2, 1999

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SUMMARY

The Commission has before it the opportunity to establish a new paradigm in its longstanding and largely successful effort to promote competition in the provision of domestic and international satellite services. The new generation of NGSO FSS Ku-band systems, such as SkyBridge, stands as a seminal advance in the efficient utilization of orbital and spectrum resources.

Of equal importance is the impact on a critical mission assigned to the Commission by Congress in Section 706 of the Telecommunications Act of 1996 -- ensuring the provision of high-speed, interactive broadband services to all Americans. For many areas of the country, the only likely means of receiving these services will be satellite systems, and most particularly, LEO satellite systems.

The international community has already endorsed, clearly and strongly, the concept of NGSO FSS operations at Ku-band. WRC-97 adopted a regulatory regime for spectrum sharing among such systems and GSO and terrestrial systems in the band, and directed various ITU-R bodies to undertake studies, with the objective of finalizing the necessary technical parameters at WRC-2000. The instant proceeding -- in conjunction with the Commission's review of the various applications now pending for NGSO FSS Ku-band systems -- will strengthen the ability of the U.S. Government to shape the details of the regulations to be adopted at WRC-2000.

SkyBridge applauds the Commission's efforts, in the NPRM, to propose an approach to sharing that is consistent with the framework established to date. While work on the final ITU regulations is ongoing, in these comments

SkyBridge proposes rules that take into account the current expert consensus regarding the various technical questions under consideration.

First, SkyBridge asks the Commission to reassess its preliminary decisions not to assign to NGSO FSS the 13.75-13.8 GHz and 17.3-17.8 GHz bands. The concerns about interference to governmental systems in these bands can all be addressed without disturbing the delicate balance already established for inter-service sharing in these bands. Furthermore, recent studies indicate that, with appropriate ground rules, NGSO FSS and BSS can amicably share the 17.3-17.8 GHz bands. With the SkyBridge proposals for the "rules of the road" for these bands, the Commission should not hesitate to allocate them to NGSO FSS systems.

SkyBridge proposes power limits (the so-called EPFD and $EPFD_{up}$ limits), derived using the most current methodologies developed by the ITU-R study groups. These limits protect the GSO FSS and GSO BSS services while avoiding undue and unnecessary constraints on NGSO FSS systems. In addition to showing how the derived limits protect the ITU-R database of links established for these studies, SkyBridge explains in detail the conservative assumptions that are made in both the methodologies used to derive the EPFD limits and in the software that will be used to assess whether a given NGSO system meets the limits. When the cumulative effect of these assumptions is taken into account, the extraordinary protection being afforded to GSO systems becomes clear.

SkyBridge also proposes rules that will protect the ability of terrestrial FS facilities to operate free of interference, and to expand their build-out well into the future. The cornerstone of SkyBridge's proposal is a carefully limited definition of

the type of NGSO FSS "gateway" operations that would be permitted in bands shared with the FS. Using traditional coordination procedures, and shielding around gateway sites as necessary, NGSO FSS gateways will be able to transmit in the shared bands without adversely impacting FS expansion. Moreover, the ITU-R studies have already essentially reached agreement on the power limits that will be applicable to NGSO satellites for the protection of FS services; SkyBridge proposes that this agreement be the basis for the adoption of rules by the Commission.

SkyBridge strongly urges the Commission to deny the request of Northpoint to reintroduce terrestrial services in the 12.2-12.7 GHz band. Northpoint's original proposal was to allow DBS affiliates to re-use the DBS band to distribute local television signals; Northpoint now appears to be completely abandoning that plan, however, in reaction to the universal opposition of the DBS community. Northpoint's new proposal represents no more than LMDS, MMDS, or DEMS by another name (indeed, Northpoint's one-way service affords the consumer significantly less than these other services) -- services for which the Commission has already allocated sufficient spectrum in other bands. Although Northpoint's filings with the Commission are completely devoid of reliable information on its system sufficient to conduct a definitive interference analysis, no reasonable variation of its system architecture will be able to avoid interference into the BSS and NGSO FSS satellite services, both of which need the band to support their ubiquitous user earth stations.

With respect to shaping a regulatory framework for licensing Ku-band NGSO FSS systems, the Commission must keep in mind that a central goal of this

proceeding should be to ensure competition in the provision of high-speed, interactive broadband services throughout the United States and the world. Both Section 706 of the 1996 Telecom Act and WRC-97 command nothing less. Thus, SkyBridge supports the Commission's view that multiple NGSO FSS systems should be accommodated at Ku-band, and urges the Commission to adopt rules that will achieve this result as expeditiously as possible. Specifically, SkyBridge proposes strict qualifications on the systems proposed by applicants, including the capabilities to: (1) employ satellite diversity to mitigate interference to and from other NGSO systems; (2) provide global coverage; (3) offer a full range of high-speed broadband services; (4) provide full two-way interactive capability; and (5) offer direct access to the system for residential and business customers via low-cost ground terminals. SkyBridge urges the Commission to apply these requirements, as well other financial and technical qualifications, in the strictest possible fashion.

Finally, SkyBridge sets out a schedule for the licensing process of these NGSO FSS systems, asking the Commission to initiate immediately technical discussions within the U.S. among the applicants, and simultaneously begin international coordination of these proposed systems. SkyBridge also urges the Commission to adopt licensee qualification rules, and apply them strictly, at the earliest possible time, with a goal of issuing licenses to qualified applicants by the close of the year, subject to compliance with the final technical and service rules.

The SkyBridge proposals will allow the Commission to expedite the attainment of the longstanding U.S. domestic and international goal of a universally available global information infrastructure, the satellite components of which can be

in operation within the time frame announced by Vice President Gore in his speech to the ITU Plenipotentiary Conference last October. The Commission can accomplish these objectives while preserving existing GSO and FS Ku-band services and ensuring their continued opportunity for growth.

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To: The Commission

COMMENTS OF SKYBRIDGE L.L.C.

SkyBridge L.L.C. ("SkyBridge"), by its attorneys, submits these comments in response to the Commission's Notice of Proposed Rulemaking (the "NPRM") in the above-captioned matter.[1/]

The NPRM was issued in part in response to a Petition for Rulemaking filed by SkyBridge on July 3, 1997 (the "SkyBridge Petition"). The Petition was filed in conjunction with SkyBridge's application to the Commission (the "SkyBridge Application") for authority to launch and operate the "SkyBridge System," a global network of nongeostationary orbit ("NGSO") communications satellites operating at

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1/ FCC 98-310, released November 24, 1998.

Ku-band, designed to provide broadband services in the Fixed-Satellite Service ("FSS").[2/]

I. BACKGROUND

A. Advancing the Public Interest

The instant rulemaking seeks to establish technical and other rules necessary to facilitate the operation of a new generation of NGSO FSS systems at Ku-band, which are able to share spectrum with geostationary orbit ("GSO") satellite systems and terrestrial Fixed Service ("FS") operations. As SkyBridge stated in its Application, the Commission has before it the opportunity to establish a new paradigm in its over twenty-year effort to promote competition in the provision of domestic and international satellite services.[3/] The new generation of NGSO FSS systems represented by SkyBridge stands as a seminal advance in the efficient utilization of orbital and spectrum resources.

The significance of the opportunity presented by the instant proceeding goes beyond rethinking old assumptions about the congested orbital arc. Of equal importance is the potential impact of this proceeding on a critical mission assigned to the Commission by Congress in Section 706 of the Telecommunications Act of 1996

[2/] Application of SkyBridge L.L.C. for Authority to Launch and Operate a Global Network of Low Earth Orbit Communications Satellites Providing Broadband Services in the Fixed-Satellite Service, File No. 48-SAT-P/LA-97, filed February 28, 1997; Amendment, File No. 89-SAT-AMEND-97, filed July 3, 1997 ("1997 Amendment"); Amendment, 130-SAT-AMEND-98, filed June 30, 1998 ("1998 Amendment"); Public Notice, Report No. SPB-141 (Nov. 2, 1998); Amendment, filed January 8, 1999 ("1999 Amendment").

[3/] See SkyBridge Application at 8-10.

(the "'96 Act"): provision of high-speed, interactive broadband services to all Americans.[4/]

As the Commission is aware, the SkyBridge System will provide residential and business users throughout the United States and the world with access to a wide array of such services. The importance of ensuring universal competitive access to these services was summarized by the Commission exactly one month ago today, in its Section 706 Report[5/]:

> One of the fundamental goals of the Telecommunications Act of 1996 . . . is to promote innovation and investment by multiple market participants in order to stimulate competition for . . . broadband communications services.
>
> * * *
>
> Widespread access to broadband capability can increase our nation's productivity and create jobs. Access to broadband can also meaningfully improve our educational, social and health care services.
>
> * * *
>
> As Congress directed, we intend to ensure that broadband capability is being deployed on a reasonable and timely basis to all Americans.[6/]

The Commission further noted in the Section 706 Report that, for many areas of the country, the only likely means of providing those critical services will be satellite systems, and most particularly, low earth orbit ("LEO") satellite systems.[7/] Vice President Gore made essentially the same point in his opening address to the

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4/ Pub. L. No. 104-104, 110 Stat. 56 (1996).

5/ Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, FCC 99-5, released February 2, 1999 ("Section 706 Report").

6/ Section 706 Report at 3-4.

7/ Id. at 28, nn.110-111.

International Telecommunications Union's ("ITU") Plenipotentiary Conference in Minneapolis in October 1998. There, the Vice President discussed at length the critical need for global access to broadband services. With an obvious nod to the new generation NGSO FSS satellite systems, the Vice President stated that, "[w]ithin three years, we will have high-speed wireless Internet access anywhere on Earth."[8/]

The establishment of appropriate technical rules for Ku-band NGSO FSS systems in the instant proceeding -- and the licensing of those systems -- represents the most effective means at the Commission's disposal for achieving these critical domestic and international goals of competitive, universally available access to high-speed, interactive broadband services. As SkyBridge made clear in its Application, it plans to initiate service to the United States and other nations in the temperate zones by the end of 2001, with full global service being offered by the end of 2002.[9/]

B. Progress Toward Technical Consensus

As the Commission is aware, the reaction in 1997 to SkyBridge's proposed new satellite system and frequency-sharing technology was mixed. Setting aside the natural competitive concerns exhibited by some, the operators of existing Ku-band GSO and FS systems expressed varying levels of concern regarding the viability of SkyBridge's frequency-sharing methodology. The potential users of the SkyBridge System -- particularly those without the benefit of an extensive terrestrial

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8/ Address of Vice President Al Gore to the Plenipotentiary Conference of the International Telecommunications Union, Minneapolis, Minnesota (October 12, 1998).

9/ SkyBridge Application at 92.

communications infrastructure -- responded to SkyBridge's proposal with considerable support.

Indeed, less than ten months after the filing of the SkyBridge Application, the international community roundly endorsed the concept of NGSO FSS operations at Ku-band. The 1997 World Radiocommunication Conference ("WRC-97"), seeking to ensure the availability of multiple NGSO FSS systems and the competitive provision of high-speed interactive broadband services, authorized the sharing of spectrum in the Ku-band, subject to technical parameters to prevent interference.[10/] WRC-97 directed that the relevant ITU bodies study these parameters so that they may be confirmed or modified as needed at the next WRC, now scheduled for the spring of 2000 ("WRC-2000").[11/]

10/ As discussed in greater detail infra, WRC-97 established an international regulatory regime for NGSO/GSO and NGSO/FS sharing, contained in Articles S21 and S22 of the ITU Radio Regulations. The core rules adopted at WRC-97 are "equivalent" power flux-density ("EPFD") and "aggregate" power flux-density ("APFD") limits applicable to NGSO FSS systems, and power flux-density ("PFD") limits applicable to each satellite in an NGSO FSS system. The values of the EPFD, APFD and PFD limits are to be reviewed at WRC-2000.

11/ WRC-97 established an international task group -- Joint Task Group 4-9-11 ("JTG 4-9-11") -- to undertake these studies and report its findings to WRC-2000. Several other ITU-R bodies have also contributed to this effort, including Working Party 4A ("WP 4A"), Joint Working Party 10-11S ("JWP 10-11S"), Working Party 4-9S ("WP 4-9S") and Working Party 9A ("WP 9A"). WP 4A and JWP 10-11S have studied issues relating to NGSO FSS sharing with GSO FSS and GSO BSS, respectively. WP 4-9S and WP 9A have studied NGSO FSS sharing with FS and other terrestrial services. JTG 4-9-11 has conducted three meetings to date -- March 1998 in Geneva, July 1998 in Toulouse, and January 1999 in Long Beach. The final JTG meeting is scheduled for May 1999.

This technical review has been ongoing ever since, and, as is detailed infra, has achieved significant progress to date. SkyBridge is convinced that, well before the commencement of WRC-2000, a consensus will be reached on essentially all necessary technical parameters for ensuring the successful co-existence of NGSO, GSO and terrestrial systems at Ku-band.

Thus, the timing of the instant NPRM is most propitious. This proceeding will enable the Commission to shape its own regulatory structure for NGSO FSS operations at Ku-band in a manner that is in harmony with the global regulatory scheme to be finalized at WRC-2000. The pendency of this proceeding, moreover -- in conjunction with the Commission's review of the various applications now pending for NGSO Ku-band systems -- should strengthen the ability of the U.S. Government to shape the details of the regulations to be adopted at WRC-2000. By virtue of its longstanding "Open Skies" policy[12/] and transparent regulatory process,[13/] the Commission again finds itself in the position of being able to establish the model for an open, pro-competitive regulatory approach that will facilitate the deployment of a new generation of satellite systems, while also achieving the statutory goal of ensuring universal access to interactive, high-speed broadband services as expeditiously as practicable.

12/ See, e.g., Establishment of Domestic Communications-Satellite Facilities by Non-Governmental Entities, 38 F.C.C.2d 665 (1972).

13/ See, e.g., Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States, 12 FCC Rcd 24094 (1997) (DISCO II Order).

II. NGSO FSS Ku-BAND FREQUENCY ALLOCATIONS

The Commission proposes to allocate, on a co-primary basis, the 10.7-11.7 GHz, 11.7-12.2 GHz, and 12.2-12.7 GHz bands for NGSO FSS downlinks, and the 12.75-13.25 GHz and 13.8-14.5 GHz bands for NGSO FSS uplinks. As discussed below, the Commission has proposed not to allocate the 13.75-13.8 GHz and 17.3-17.8 GHz bands for NGSO FSS gateway operations, in order to protect certain U.S. government operations. Without these bands, however, the ability of the allocated spectrum to support multiple commercially-viable NGSO FSS systems is seriously threatened.[14/] Particularly given the fact that, as demonstrated below, NGSO FSS operations can operate in these bands without harming any of the U.S. government operations cited in the NPRM, there are compelling public interest reasons for the Commission to reassess its initial views regarding these bands.

[14/] For example, as noted in SkyBridge's 1998 Amendment, system design changes have already been required to address increasing projections on capacity demands. Without the 13.75-13.8 GHz and 17.3-17.8 GHz bands, the ability of the SkyBridge System to adequately serve "hot spots" (i.e., those gateway cells with the highest expected traffic), would be severely compromised. In these high traffic growth areas, saturation would be reached within a few years into the life of the system. Such a situation would not be in the public interest. Furthermore, several applicants in the current Ku-band NGSO FSS processing round have requested access to this spectrum in order to meet their uplink bandwidth requirements (up to 1.65 GHz). Even including the 13.75-13.8 GHz and 17.3-17.8 GHz bands, only 1.75 GHz of uplink bandwidth is available in this round. Therefore, eliminating these bands would severely constrain the development of systems and services in this band. In order to facilitate sharing, maximize system entry, and ensure adequate spectrum for competitive services, these bands must be allocated to NGSO FSS systems.

A. 13.75-14.0 GHz

The 13.75-14.0 GHz band is currently allocated to Radiolocation and FSS on a co-primary basis, and to Space Research on a secondary basis,[15/] subject to certain sharing criteria described below. Pursuant to these allocations, the band is currently used by U.S. government radars and NASA's Tracking Data and Relay Satellite System ("TDRSS"). For the reasons discussed infra, SkyBridge agrees with the Commission that NGSO FSS gateway uplink operations should be able to share the 13.8-14.0 GHz band with incumbent government and GSO FSS operations, subject to proper coordination and spectrum sharing criteria.[16/] SkyBridge does not agree, however, that NGSO FSS operations will not be able to protect NASA's TDRSS downlinks to the space shuttle in the 13.75-13.8 GHz band,[17/] and urges the Commission to allocate this band for NGSO FSS gateways.

1. Application of S5.502 and S5.503 to NGSO FSS Gateways

At WRC-95, ITU Radio Regulations footnotes S5.502, S5.503, and S5.503A[18/] were adopted to facilitate compatibility between the services in the

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15/ However, GSO Space Research space stations for which advance publication information was received by the ITU prior to January 31, 1992 operate on an equal basis with FSS. See Radio Regulations footnote S5.503 and US Table of Allocations footnote S5.503, 47 C.F.R. § 2.106 ("U.S. Table of Allocations").

16/ NPRM, ¶ 39.

17/ NPRM, ¶¶ 19, 39, 41-43.

18/ These international footnotes are also included in the U.S. Table of Allocations.

13.75-14.0 GHz band. S5.502 spells out the current "rules of the road" for this band:

- The equivalent isotropically radiated power ("EIRP") of any emission from an FSS earth station must be at least 68 dBW, in order to protect the associated space station from Radiolocation emissions.
- The EIRP of any emission from an FSS earth station should not exceed 85 dBW, in order to protect Radiolocation emissions.
- FSS earth stations should have a minimum antenna diameter of 4.5 meters, in order to preclude deployment of ubiquitous FSS earth stations, such as VSAT terminals, and to minimize the impact of off-axis radiation into other services, taking into account the above maximum EIRP levels.

The Commission has proposed to apply these requirements to NGSO FSS operations in this band.[19/]

SkyBridge believes that certain modifications to these rules, as applied to NGSO FSS systems, are needed. Although NGSO FSS operators may be able to adjust their operations to comply with these requirements, doing so may adversely affect existing services in the band. Most importantly, adherence to the 68 dBW EIRP floor may require unnecessarily high NGSO FSS uplink powers, to the detriment of the Space Research operations in the band, such as TDRSS.

Moreover, these requirements were developed with specific GSO FSS systems in mind. The 68 dBW EIRP restriction, designed for the protection of the FSS system, bears no relation to the protection requirements of NGSO FSS systems.[20/] It therefore serves no useful purpose when applied to such systems.

19/ NPRM, ¶ 42.

20/ It is even difficult to extrapolate the analysis of Recommendation ITU-R S.1068, which derives this requirement, to GSO FSS links not considered at the time.

SkyBridge believes that S5.502 can be modified to better accommodate NGSO FSS gateway operations, without upsetting the delicate balance among the services established at WARC-92 and confirmed at WRC-95. As described below, NGSO FSS operations can co-exist with Radiolocation, while operating below 68 dBW. As discussed at the recent JTG 4-9-11 meeting in Long Beach, one option would be to replace the minimum EIRP requirement with a regulation that would preclude the NGSO FSS from claiming protection from the Radiolocation service in the 13.75-14.0 GHz band.[21/] The appropriate value of the EIRP floor for NGSO FSS systems also needs to be addressed.

SkyBridge proposes that, until such time as footnote S5.502 of the ITU Radio Regulations is modified, the Commission take the simple step of adding a footnote to the U.S. Table of Allocations as follows:

> US [#] In the frequency band 13.75-14.0 GHz, the e.i.r.p. of any emission from an earth station to a non-geostationary satellite in the fixed-satellite service may be less than the minimum value (68 dBW) specified in S5.502 of this table of allocations; however, any such emission with an e.i.r.p. of less than 68 dBW shall not be entitled to claim protection from operations in the radiolocation service.

The intent of this footnote would also need to be reflected in 47 C.F.R. § 25.204(f). After ITU Radio Regulation footnote S5.502 is modified, SkyBridge proposes that the Commission conform S5.502 in the U.S. Table of Allocations with the new version of

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21/ See Document 4-9-11/TEMP/48(Rev.1) (Long Beach). SkyBridge is proposing to allow only FSS gateway earth stations, and not ubiquitous user terminals, in this band, consistent with the philosophy of S5.502. For this reason, SkyBridge is not proposing any change to the 4.5 meter antenna requirement in S5.502, even though compliance with that standard may impose otherwise unnecessary costs on NGSO FSS operators.

the international footnote, and appropriately modify other relevant parts of the Commission's rules.

2. NGSO FSS Gateway Sharing with Radiolocation

Recommendation ITU-R S.1068 defines the characteristics of radars in the 13.75-14.0 GHz band. These radars, primarily shipborne, may emit high levels of EIRP (up to 79 dBW) toward an NGSO satellite, generating interference on the NGSO uplink, even if the link is operating with an EIRP of 68 dBW, as required by S5.502.[22/] SkyBridge believes, however, that NGSO FSS systems can coexist with such radars, without a reduction in quality of service, and without any burden on the radar operators.

The factors that must be considered in assessing the compatibility of NGSO FSS and Radiolocation systems are: (1) the impact of the interference level on the NGSO system (the duration of the interference events being one key parameter); and in the case of interference levels suggesting a problem: (2) the probability of the occurrence of such events; and (3) the ability of the NGSO satellite to withstand "overdrive" in the event of a radar "hit."

First, the duration of an interference event to an NGSO satellite from these radars will be quite brief, on the order of a few microseconds.[23/] In the case of the SkyBridge System, the error coding scheme can handle such interference so that the end users will not be affected. Moreover, SkyBridge's analysis indicates that the probability that a radar will transmit towards a satellite being used by an NGSO earth

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[22/] See Documents 4-9-11/97 and 4-9-11/277.

[23/] See Recommendation ITU-R S.1068.

station is at most 1.5×10^{-5}.[24/] The final concern for NGSO FSS systems is the ability of the transponders to resist overdrive due to a radar hit. In the 13.75-14.0 GHz band, the peak radar EIRPs are on the order of 79 dBW, and no harm will be caused to the SkyBridge transponders.[25/]

In sum, NGSO FSS satellites can co-exist with Radiolocation in the 13.75-14.0 GHz band.[26/] Importantly, such co-existence does not depend on the use of a 68 dBW EIRP by the NGSO FSS uplinks in the 13.75-14.0 GHz band. As discussed below, use of lower powers by NGSO FSS uplinks will aid in protecting

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[24/] See Document 8B/83, a recent update of Document 4-9-11/241. SkyBridge's purely geometrical analysis is applicable to any NGSO FSS system. It uses the radar characteristics contained in Rec. ITU-R S.1068. The analysis is based on the worst-case configuration of the radar being co-located with the NGSO FSS earth station. This scenario is worst-case because, whenever a satellite is followed by the earth station, it is in visibility of the radar. It also assumes that the pointing direction of the radar is random (above the horizon). The radar beams used in the 13.75-14.0 GHz band have high discrimination in azimuth and low discrimination in elevation. The analysis therefore assumes that the aperture of the transmitter is 2° and that five transmitters operate simultaneously along an elevation cut. The radar duty cycle is assumed to be 1%.

[25/] As discussed below, in the 17.3-17.7 GHz band, where higher power radars are used, protection can be built into the transponders to ensure that no harm is caused by the radars.

[26/] To the extent necessary, SkyBridge would accept a domestic requirement to coordinate U.S. NGSO FSS gateway earth stations with the government radars through the Frequency Assignment Subcommittee ("FAS") process of the Interdepartmental Radio Advisory Committee ("IRAC"), as the Commission has proposed. NPRM, ¶ 42. However, because time is of the essence in deploying these new NGSO FSS systems, SkyBridge urges the Commission, as a member of IRAC, to take steps to ensure that the FAS process is conducted in the most expedient and efficient manner possible to avoid delay. No coordination of the SkyBridge space stations would be necessary in this band.

TDRSS downlinks to the space shuttle and GSO uplinks, and ease coordination among NGSO systems.

3. NGSO FSS Gateway Sharing with TDRSS

In the NPRM, the Commission declined to assign the 13.75-13.8 GHz band to NGSO FSS operations, due to concerns regarding the ability of such systems to protect the TDRSS downlinks to the space shuttle.[27] SkyBridge believes, however, that its system will fully protect the TDRSS system within its system requirements, as specified in Recommendation ITU-R SA 1155.

On the basis of the TDRSS system description in ITU-R SA 1155 and in Document 4-9-11/130, SkyBridge has performed simulations to assess its ability to meet the TDRSS protection criteria.[28] In its simulations, presented in Appendix E hereto, SkyBridge gateway transmissions complied with the minimum 68 dBW EIRP requirement imposed by S5.502 in this band. The simulations also employed the conservative assumptions that: (1) over 400 SkyBridge gateways are deployed worldwide (in fact, SkyBridge expects deployment of only 200 gateways worldwide[29]); and (2) three SkyBridge satellites are tracked by each gateway (in those latitudes where there are 3 satellites available 100% of the time). Even under these very pessimistic assumptions, the SkyBridge System can meet the protection

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[27] NPRM, ¶¶ 14, 39, 41-43.

[28] These simulations employ TDRSS parameters updated from those used in its previous analytical studies (see, e.g., 1997 Amendment), which made some incorrect assumptions about the TDRSS system.

[29] 1999 Amendment at A-49. Furthermore, SkyBridge plans to use this band for high traffic cells, limiting the number of gateways that will operate co-frequency with TDRSS.

requirements of the TDRSS system defined in ITU-R SA 1155.[30/] Furthermore, as discussed above, modification of S5.502 to protect Radiolocation without the need for the 68 dBW minimum EIRP requirement on FSS earth station emissions would improve the sharing situation considerably.

Based on these results, SkyBridge urges the Commission to reverse its decision not to assign the 13.75-13.8 GHz band to NGSO FSS systems. Rather, the Commission should conform its NGSO FSS allocations to those adopted internationally by the ITU at WRC-97, which include the 13.75-13.8 GHz band. In order to protect the TDRSS system, the Commission should apply footnote US 337 in the U.S. Table of Allocations to NGSO FSS systems, requiring such systems to coordinate on a case-by-case basis through the FAS of IRAC to minimize harmful interference to TDRSS downlinks.[31/] This will limit entry of NGSO FSS systems in the band to those systems designed to protected TDRSS operations.

30/ Although the TDRSS protection requirement is an aggregate one, using more realistic assumptions on the operation of the NGSO FSS systems, it is likely that more than one system could collectively meet the requirement.

31/ Such coordination is currently required to protect TDRSS wideband operations. To protect narrowband operations, S5.503 limits the maximum EIRP density in the 13.772-13.778 GHz band to 71 dBW/6 MHz. SkyBridge proposes that this requirement also be applied to NGSO FSS systems.

B. 17.3-17.8 GHz

The 17.3-17.7 GHz band is allocated on a secondary basis to Radiolocation. In ITU Region 2, the 17.3-17.8 GHz band is currently allocated on a co-primary basis to FSS, for use for BSS feeder links only,[32] and is allocated on a co-primary basis for BSS downlinks, effective April 1, 2007.[33] The 17.7-17.8 GHz band is also allocated to FS on a co-primary basis.

The Commission has declined to allocate the 17.3-17.8 GHz band to NGSO FSS gateway operations due primarily to concerns that such operations will be subject to interference from government radars operating in that band.[34] The Commission also has tentatively determined that NGSO FSS gateway operations can not share with BSS downlinks, and requests comment on that conclusion.[35]

1. NGSO FSS Gateway Sharing with Radiolocation

Some radars in the 17.3-17.7 GHz band may emit powers up to about 116 dBW.[36] Such high powers are used by radars that track space objects, including satellites. As in the 13.75-14.0 GHz band, however, SkyBridge believes that NGSO FSS gateway operations can coexist with even such high-power radars.[37]

32/ ITU Radio Regulations footnote S5.516.

33/ ITU Radio Regulations footnote S5.517.

34/ NPRM, ¶¶ 14, 51.

35/ NPRM, ¶¶ 48-50.

36/ See Documents 4-9-11/86 and 4-9-11/276.

37/ See Document 8B/83, a recent update of Document 4-9-11/241.

The higher power radars in operation in the 17.3-17.7 GHz band are few in number, have high antenna gain, and are thus very directive.[38] Therefore, the probability of an in-line event with an NGSO FSS satellite is very low. SkyBridge estimates the probability to be at most 3×10^{-6},[39] even lower than in the case of the 13.75-14.0 GHz band. Due to the higher powers of the radars in the 17.3-17.7 GHz band, the input section of transponders may saturate, but for short periods only. SkyBridge can build protection into the SkyBridge satellite receiver to resist overloading by high power radar pulses.

Because these radars are used to track space objects, SkyBridge proposes that operational coordination take place between the NGSO FSS systems and the radiolocation operators to avoid prolonged exposure by NGSO satellites to the radar beams.[40] One approach is for NGSO FSS operators to provide ephemeris data on their systems to space-tracking radar operators, so that the radars will be able to quickly recognize the NGSO satellites, and avoid tracking them for extended periods.[41]

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[38] Document 4-9-11/276.

[39] See Document 8B/83.

[40] As in the case of the 13.75-14.0 GHz band, SkyBridge would also accept a requirement to coordinate the gateways in this band with Radiolocation radars on the terrestrial path through the FAS of IRAC. See supra note 26.

[41] No such coordination would be required in the case of radars that would not track the NGSO FSS satellites.

Finally, although Radiolocation is secondary in this band, SkyBridge is sufficiently confident with regard to the above-described mitigation/coordination techniques that it would accept a footnote in the U.S. Table of Allocations, similar in concept to S5.502, that would specify the "rules of the road" for shared use of this band by NGSO FSS and Radiolocation systems based on a definition of the interference environment.[42/] Such a footnote would thereby preclude NGSO FSS systems from claiming protection from the high power government Radiolocation radars in this band, so long as both systems are operating within the requirements of the footnote.

With implementation of such measures, NGSO FSS gateway operations can co-exist with Radiolocation in the 17.3-17.7 GHz band, with minimal burdens on radar operation, and without reducing the NGSO FSS quality of service.

2. NGSO FSS Gateway Sharing with BSS

As noted above, in Region 2, the 17.3-17.8 GHz band is allocated for BSS downlinks, effective April 1, 2007. DirecTV has already applied to use the band for expansion capacity,[43/] and has filed a Petition for Rulemaking to allocate the

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[42/] Such a footnote could specify, for example, a maximum NGSO FSS power (a minimum EIRP level may not be needed as operation should be permitted so long as the NGSO FSS operator does not claim protection from Radiolocation operators). The footnote should also specify maximum radar powers, taking into account current radar operations. To preclude deployment of ubiquitous FSS stations, the footnote should specify that NGSO FSS use of the band is limited to gateway operation only. Finally, the footnote should require, in the case of space-tracking radars, that the parties undertake operational coordination to avoid tracking, to the maximum extent possible, the NGSO FSS satellites.

[43/] Application of DirecTV Enterprises, Inc. for Authority to Construct, Launch (continued...)

spectrum for BSS prior to the April 1, 2007 date.[44/] In that context, and in a recent rulemaking concerning the 18 GHz band,[45/] the Commission has received comments on the advisability of allocating the band to BSS, and the ability of BSS downlinks to co-exist with other existing and proposed uses of the band.

SkyBridge has urged the Commission to refrain from prematurely allocating the 17.3-17.8 GHz band to BSS, so that the impact on other services can be ascertained, and the spectrum can be put to its most efficient uses.[46/] In the NPRM, the Commission tentatively concluded that sharing between ubiquitous BSS downlink-to-subscriber operations and NGSO FSS gateway uplink operations would not be

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43/ (...continued)
and Operate an Expansion System of Direct Broadcast Satellites, File No. 75/76/77-SAT-P/LA-97, filed June 5, 1997 (the "DirecTV Application").

44/ Petition of DirecTV Enterprises, Inc. to Amend Parts 2, 25 and 100 of the Commission's Rules to Allocate Spectrum for the Fixed-Satellite Service and the Broadcasting-Satellite Service, RM-9118, filed June 5, 1997 (the "DirecTV Petition").

45/ Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use, IBM Docket No. 98-172, RM-9005, RM-9118.

46/ SkyBridge Comments in IBM Docket No. 98-172, RM-9005, RM-9118, filed November 19, 1998 ("SkyBridge Comments"); Reply Comments filed December 21, 1998. In particular, SkyBridge noted that there has been no showing whatsoever that BSS operators have exhausted, or will exhaust, the BSS capacity afforded by the current allocations. SkyBridge Comments at 4.

possible.[47] SkyBridge does not agree with the Commission's assessment, for the following reasons.[48]

Sharing among BSS downlinks and gateway uplink operations is in fact already envisioned. The band is currently allocated and used for BSS feeder links. In DirecTV's Petition, DirecTV stated that sharing with existing GSO gateway operations in the band is possible so long as the gateways have a good antenna pattern, a limited EIRP and a RF fence, and are not numerous.[49]

SkyBridge believes that this conclusion holds true for NGSO FSS gateways. While required separation distances will need to be maintained around each NGSO FSS gateway in the band (as exist around each BSS feeder link earth station), SkyBridge believes that such distances will be quite limited, and will not significantly burden BSS operations.[50] Recent studies by both the U.S. and French administrations as part of the JTG 4-9-11 process have shown that the separation distance between NGSO FSS gateways and BSS receive earth stations will be on the

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[47] NPRM, ¶¶ 48-50.

[48] However, SkyBridge does agree with the Commission that sharing between ubiquitous BSS downlink operations and ubiquitous NGSO FSS uplink operations would not be practical. NPRM, ¶ 48.

[49] DirecTV Petition at 9. In SkyBridge's comments on the DirecTV Petition, SkyBridge assessed the burden of maintaining minimum coordination distances between SkyBridge gateways and BSS subscriber dishes, on the basis of information provided in the DirecTV Application. Comments of SkyBridge, RM-9118, July 31, 1997, Appendix A.

[50] The separation distances between NGSO FSS gateways and BSS subscriber earth stations are expected to be smaller than the separation distances between GSO BSS feeder links and BSS subscriber earth stations. See Document 4-9-11/271.

order of tens of kilometers, depending on the NGSO FSS gateway and BSS earth station characteristics. Studies are being undertaken to more accurately quantify these constraints.[51/]

Furthermore, in order to protect FS expansion, the Commission has proposed a strict definition for "gateway,"[52/] which will act to ensure that the number of NGSO FSS gateways is quite small. In addition, based on the gateway design SkyBridge has adopted to facilitate sharing with FS stations, the Commission is proposing quite tight antenna patterns for gateway earth stations,[53/] which will also facilitate sharing with BSS. Finally, as discussed in Section V.A below, NGSO FSS gateways generally are not located in heavily populated areas.

In problematic cases, natural and artificial shielding can be used to reduce the separation distance to a few kilometers. Should the Commission decide that BSS entry in the band starting in 2007 is in the public interest, SkyBridge could propose a similar shielding procedure to that outlined in Section V.A.2.b below to facilitate sharing with FS systems.

As a result of such cooperative measures, separation distances are expected to be small, and effect only a few sites, remote from heavily populated areas. Such minimal constraints are a small price to pay for the dramatically increased spectrum efficiency sharing would provide. In addition, promoting sharing between GSO BSS and NGSO FSS in this band will further Congress' mandate to

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51/ See Document 4-9-11/TEMP/75 (Long Beach).

52/ See infra Section V.A.1.

53/ See infra Section VII.C.

expand access to interactive broadband services, especially to Americans living in rural and remote areas.[54/] For these reasons, the Commission should allocate the 17.3-17.8 GHz band to NGSO FSS, for gateway operations only.

C. Gateways vs. Service Link Operations

1. User Terminal Operation in the 14.4 - 14.5 GHz Band

The Commission tentatively proposes to restrict use of the 14.4-14.5 GHz band to gateway operations only, but requests comment on whether NGSO FSS user terminals could be accommodated in this band.[55/] SkyBridge believes that user terminals could successfully be introduced in this band, and urges the Commission to permit such use. As the Commission notes, unlike the 10.7-11.7 GHz and 12.75-13.25 GHz bands, in which user terminals will be excluded, the 14.4-14.5 GHz band is not allocated for co-primary FS operations. Unlike the 13.75-14.0 and 17.3-17.7 GHz bands, there is no use of the band by governmental radars.

Furthermore, user terminal frequencies are scarce in the Commission's proposed plan. For this reason, SkyBridge plans to use the 14.3-14.5 GHz band not only for gateways, but also for its larger professional user terminals.[56/] Because of the narrow definition of a "gateway earth station complex," such use would be precluded by the Commission's proposal. Because there is no rational reason not to

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54/ See Section 706 Report at 3-4; Teledesic Corporation, 12 FCC Rcd 3154 (Int'l Bur 1997) ¶ 2.

55/ See NPRM, ¶ 46.

56/ See SkyBridge 1997 Amendment at 9.

permit user terminals in the 14.4-14.5 GHz band, SkyBridge urges the Commission to allow operation of user terminals in this band.

2. Gateway Operation in 10.7-11.7 and 14.0-14.5 GHz Bands

The Commission, in its proposed allocations for NGSO FSS in the Ku-band, has drawn bright lines between "gateway" and "service" links.[57/] SkyBridge fully agrees that, for protection of FS and other services, certain bands should be reserved solely for gateway operations. But there is no reason why, in the nominal service link bands, gateway operations should not also be permitted.[58/] Thus, SkyBridge proposes that gateway operation be permitted in all of the bands allocated to NGSO FSS.[59/]

57/ However, the Commission proposes to permit both gateway and user terminal operations in the 14.2-14.4 GHz band. NPRM at ¶¶ 10, 66.

58/ The Commission proposed to permit NGSO service links in the 14.0-14.4 GHz band and NGSO gateways in the 14.4-14.5 GHz band. NPRM, ¶ 10. In fact, SkyBridge has proposed to operate gateways (as well as professional user terminals) in the 14.3-14.5 GHz band. See, e.g., 1997 Amendment at 9, 1999 Amendment at A-20. This discrepancy is inconsequential, however, if the Commission adopts SkyBridge's proposal to permit gateway operations in all bands allocated to NGSO FSS.

59/ Therefore, in the Commission's proposed Section 25.209(h), the reference to the operating bands for gateway earth station antennas should refer to all of the Ku-band frequencies ultimately allocated to NGSO FSS, and not just to those bands in which non-gateway operations are prohibited (see Section VII.C below).

D. NG 104

In view of its conclusion that non-ubiquitous NGSO FSS gateway operations can share with FS operations, the Commission proposes to amend U.S. footnote NG 104 to permit domestic NGSO FSS systems to operate in the 10.7-11.7 GHz and 12.75-13.25 GHz bands.[60/] SkyBridge fully supports this proposal.

60/ NPRM, ¶¶ 17, 33.

III. NGSO FSS SHARING WITH GSO FSS

As described above, WRC-97 adopted provisional single entry EPFD and APFD limits in Article S22 of the Radio Regulations in order to facilitate NGSO FSS entry into the subject Ku-band frequencies.[61/] Resolution 130 of WRC-97 called for a review of these provisional limits. JTG 4-9-11 and WP 4A have been conducting the necessary studies to assess the adequacy of the WRC-97 limits to protect GSO FSS operations, without imposing undue burdens on NGSO FSS systems. Several areas of study have been explored in parallel to arrive at a methodology for deriving and confirming EPFD and $EPFD_{up}$ (formerly APFD[62/]) limits:

- The protection criteria and methodology to derive the limits;
- The aggregate impact of several NGSO FSS systems;
- The maximum number of NGSO FSS systems that can operate co-frequency;
- The GSO links used to confirm the adequacy of "candidate" limits; and
- The form of the limits (i.e., points or continuous mask).

61/ The Commission notes that WRC-97 developed Article S22 based on the avoidance of "unacceptable" interference to incumbent services. Therefore, the Commission proposes that the sharing criteria (i.e., the EPFD and $EPFD_{up}$ limits), including provisions necessary to take into account any exceptional cases, constitute an acceptable level of interference under the Commission's rules. (The Commission also proposes to equate the term "accepted" interference, as used by the Commission in various rules (e.g., 47 C.F.R. § 2.1), with the term "acceptable" interference, as more commonly used for international satellite coordinations.) NPRM, ¶ 28. SkyBridge agrees with this approach. The EPFD and $EPFD_{up}$ limits define the level of acceptable interference and constitute the hard limits applicable to NGSO FSS systems. They are not coordination triggers subject to further negotiation on a case-by-case basis.

62/ See Section III.D below.

SkyBridge sets out below the results of these studies to date, and uses the results to derive EPFD masks and $EPFD_{up}$ limits for protection of GSO FSS systems.

A. Results of ITU-R Studies

1. Protection Criteria and Methodologies

In order to determine whether a given set of EPFD or $EPFD_{up}$ limits protects a given GSO link, a standard criteria of protection is required. WP 4A has developed a recommendation for such a criteria, which has been used by the JTG 4-9-11 in its work to-date. In its most current draft form, this Preliminary Draft Revision to Recommendation ITU-R S.1323 recommends that all NGSO systems (in the aggregate) should:

- contribute at most 10% of the time allowances for the bit error rate ("BER") or carrier-to-noise ratio ("C/N") specified in the short-term performance objectives of the GSO network,[63] and
- not lead to loss of synchronization in the GSO network more than once per x days (the value of x to be determine in further studies).[64]

A methodology is required in order to derive candidate limits, and then assess whether the S.1323 criterion is met[65] with such limits for a given GSO link. A

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[63] The Preliminary Draft Revision to Rec. ITU-R S.1323 from the last WP 4A meeting includes a footnote stating that in the case where the degradation of performance due to the link fading and the long term interference power level has a probability lower than the allocated 90% of the total probability of degradation, the difference between the actual probability and 90% of the total probability of degradation should be allocated to the external source of interference.

[64] Document 4A/TEMP/47(Rev.1).

[65] In order to assess if this criterion is met, in deriving the EPFD limits

(continued...)

variety of methodologies may be used to derive candidate limits. Recommendation S.1323 contains several options (denoted Methodologies A, A', and B). JTG 4-9-11 has concluded that use of any of these methodologies is appropriate as a starting point.[66/] For assessing whether candidate limits meet the Recommendation S.1323 criterion for the GSO links under consideration, S.1323 and the JTG have prescribed a single methodology (denoted Methodology D or Procedure D).[67/] In order to refine limits that are either not adequate to protect the GSO links, or are overly protective and hence overly constraining on NGSO systems, Methodology D is used interactively, in a trial and error fashion, until appropriate limits are produced.

2. Aggregate Impact of Multiple NGSO Systems

Methodology D is used to (1) derive and (2) assess "aggregate" limits, taking into account the interference from all NGSO FSS contributors. As recognized by WRC-97, however, single entry limits are required. Use of solely an aggregate mask in the Radio Regulations could lead to a situation where the first entrant takes all of the acceptable allowance for itself, thereby precluding the use of the bands by

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65/ (...continued)
presented below, SkyBridge used the approach left in brackets in Addendum 1 to Document 4-9-11/TEMP/65 (Long Beach), which specifies how to treat cases where the time percentage of unavailability of the GSO link, without NGSO interference, is above or below 90% of the time percentage corresponding to its availability target.

66/ Document 4-9-11/TEMP/65, Addendum 1 (Long Beach) and Document 4-9-11/TEMP/55(Rev.1) (Long Beach).

67/ Id.

multiple NGSO systems, and thwarting the goal of WRC-97 to achieve multiple NGSO systems in the band.[68/]

The ITU-R study groups have gained considerable insight into how the interference from multiple NGSO FSS systems aggregates, and have proposed to use this knowledge to appropriately divide the aggregate limits analyzed using Methodology D of Recommendation ITU-R S.1323 to obtain single entry limits for inclusion in Article S22. It has been demonstrated that the aggregation of interference varies depending on the percentage of time under consideration. Three "zones" have been identified.[69/] First, for the longer percentages of time (representing the "long term" or usual situation), the interference powers from the NGSO systems add in power ("Zone A"). For shorter percentages of time, the signals do not add in power, but do add in time ("Zone B"). Importantly, this means that the powers for the 100% (never to be exceeded) limits do not aggregate. For the shortest percentages of time, simulations have shown that the powers do not add in either power or time, and the aggregate tends to be dominated by the worst-case NGSO FSS system for a given GSO earth station location and pointing direction ("Zone C").

Therefore, converting aggregate limits to single entry, and vice versa, must be performed on a zone-by-zone basis. The boundaries of these regions depend on the size of the GSO antenna under consideration, and the characteristics of the

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[68/] See Resolution 130 of WRC-97, considerings g), i), and k).

[69/] Document 4-9-11/TEMP/65, Addendum 2 (Long Beach) and Document 4-9-11/TEMP/59(Rev.1) (Long Beach).

NGSO systems modeled.[70] However, as shown in Appendix A, SkyBridge uses a method for deriving single entry limits from an aggregate mask that does not depend on the actual boundaries, as it employs worst-case transition points.

3. Maximum Number of Co-Frequency NGSO Systems

Determining the maximum number of NGSO systems that can operate co-frequency has been among the most difficult tasks faced by the ITU-R study groups. No definitive agreement on a number "N" of systems that can actually operate co-frequency has been reached. This is because the ability of NGSO FSS systems to share depends critically on the characteristics of each of the NGSO FSS systems under consideration. Furthermore, in the general case, NGSO FSS systems must expend resources to share, with consequent reductions in capacity.[71] The constraints on NGSO systems increase as the number of systems increases. Such technical studies inevitably require assumptions regarding certain yet-to-be established regulatory policies.

Despite these obstacles, significant progress has been made. First, the study groups have recognized that the number of systems that can share depends on whether the systems operate with coordinated orbital parameters (i.e., are homogeneous). WP 4A concluded that preliminary studies suggest that "several (e.g.,

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[70] In some cases, therefore, Zone C is very small. For this reason, SkyBridge does not use Zone C in derivation of all limits, but only those for which Zone C plays an important role (i.e., the limits for the larger GSO earth stations).

[71] To date, most studies have not considered the need for each NGSO system simultaneously to implement mitigation techniques to protect the GSO arc and to protect each other. The JTG has urged administrations to include such complexities in future studies. Document 4-9-11/TEMP/77 (Long Beach).

three) truly homogeneous NGSO FSS systems might be able to share frequencies," but that "the number of NGSO systems employing different orbital characteristics . . . would probably be smaller than the number of co-frequency systems that can share using homogeneous orbits."[72] Looking at the reality of the actual systems proposed to date, the JTG has agreed to consider only the situation of non-homogeneous orbits.[73]

Furthermore, the results of these studies indicate that even if it would be technically feasible to operate more than three non-homogeneous NGSO systems co-frequency, severe technical constraints would be imposed, perhaps threatening the economic viability of the systems. The need for each system to be able to maintain its designed capacity and cost objectives in a sharing environment is an important determinant of N. Based on these observations, SkyBridge urges the Commission to adopt 3 as the value of N to use for deriving the limits.

It should be noted that the JTG has agreed on the following principles regarding "N":[74]

- An equivalent number "$N_{effective}$" of systems should be considered for the purposes of studying the impact of aggregate interference from multiple non-GSO FSS systems, under the assumption that each system operates at the single entry EPFD limits.[75]

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[72] Document 4A/TEMP/75(Rev.1).

[73] Document 4-9-11/TEMP/77 (Long Beach).

[74] Id.

[75] In order to ensure proper application of the limits and the regulatory procedure for coordination among systems, it is necessary to have unambiguous guidelines for what constitutes an NGSO "system." SkyBridge proposes a (continued...)

- The actual number of systems "$N_{physical}$" that can operate co-frequency could be larger than the equivalent number "$N_{effective}$" of systems.

- There is a need for the development of a regulatory regime (WRC-2000 Resolution) that would allow for more than "$N_{effective}$" systems to be deployed in a particular band (i.e., $N_{physical} > N_{effective}$), while still ensuring that the aggregate limits are met. This Resolution would take the form of a coordination procedure that would permit non-GSO systems to coordinate amongst themselves, while ensuring that the aggregate EPFD mask into GSO networks is still met.

The international regime contemplated by the JTG would have the objective of allowing NGSO systems to coordinate amongst themselves[76/] to permit additional entry, while ensuring that the aggregate mask is still met. The details of the coordination procedure remain to be finalized at the international level.

4. GSO Links to be Used to Confirm Adequacy of Limits

As the JTG 4-9-11 has recognized, it is clearly impractical to gather and analyze data on all existing and planned GSO links. In order to identify for study potentially sensitive links, the JTG, at its first meeting, developed two spreadsheets to aid administrations in evaluating and submitting links to the JTG. Parameters listed in Annex 1 to Circular Letter 92 are to be used by administrations to perform an initial assessment of the impact of interference from an NGSO FSS system to a GSO

75/ (...continued)
standard that both prevents dissection of an NGSO satellite constellation into smaller systems (either on an orbital or geographic basis), and requires combination of systems that have an interconnected control system or integrated service provision. In both cases, the system as a whole should be considered a single system, and should be required to meet the EPFD and $EPFD_{up}$ limits on that basis.

76/ See Radio Regulations S9.12 which governs coordination between NGSO systems.

link. Should this assessment identify a potentially sensitive link, administrations were strongly urged to provide as much information as possible on the link, preferably at least the parameters in Annex 2, so that the link could be taken into consideration by the ITU-R study groups. Methodology D, the tool to be used for refining and validating the limits, uses as an input the Annex 2 characteristics of the GSO FSS links.

The JTG has agreed, therefore, to use the database of Annex 2 data it has compiled to assess the adequacy of candidate limits.[77] A deadline of March 15, 1999, has been established by the JTG for submitting GSO link data in this form.[78]

It is vitally important that the complete Annex 2 data be used to assess the protection of sensitive links. This is because, as discussed below, a number of conservative and simplifying assumptions are made in the methodologies used to derive limits.[79] It is simply not the case that a link that may initially appear less protected will necessarily be so in practice. Examination of a link in detail often brings to light features of the link that will act to ensure its full protection. For these reasons, SkyBridge urges the Commission to employ Annex 2 data when considering whether candidate limits are adequate to protect any given GSO link.

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[77] Document 4-9-11/367 (Chairman's Report).

[78] See Document 4-9-11/TEMP/92(Rev.1) (Long Beach).

[79] See Section III.C.1 below.

5. Form of Limits

JTG 4-9-11 has concluded that the WRC-97 specification of EPFD limits for only a discrete number of time percentages, with "staircase" interpolation between these limits, overestimates the interference generated by NGSO FSS systems. Instead, the JTG proposes to define continuous EPFD masks, defined for all time percentages, to better represent the statistical nature of NGSO interference.[80/] Such masks also address the need of some GSO operators employing small earth stations for limits governing the true "long-term" situation. SkyBridge proposes that the Commission follow the JTG conclusion, and adopt EPFD masks, instead of discrete limits, in its rules.

In addition, SkyBridge proposes that the Commission adopt EPFD masks for more than the three GSO earth station antenna sizes specified by WRC-97. This will help ensure protection of GSO antennas of intermediate sizes. Below, SkyBridge proposes masks for 1.2 m and 5 m antennas, in addition to the reference WRC-97 sizes of 60 cm, 3 m, and 10 m.

B. EPFD Limits

Employing the above methodology and techniques, SkyBridge has derived aggregate EPFD masks that adequately protect GSO FSS systems within the dictates of Recommendation ITU-R S.1323, while accommodating entry of multiple NGSO FSS systems in the band. From these aggregate masks, single entry masks are

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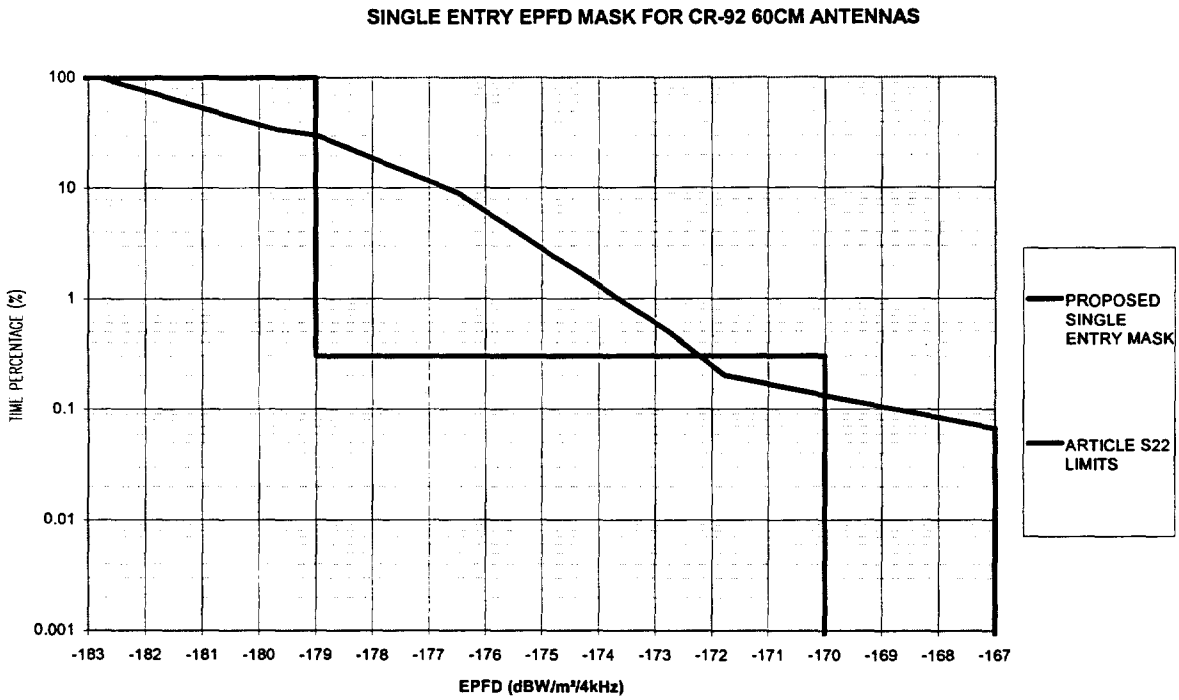
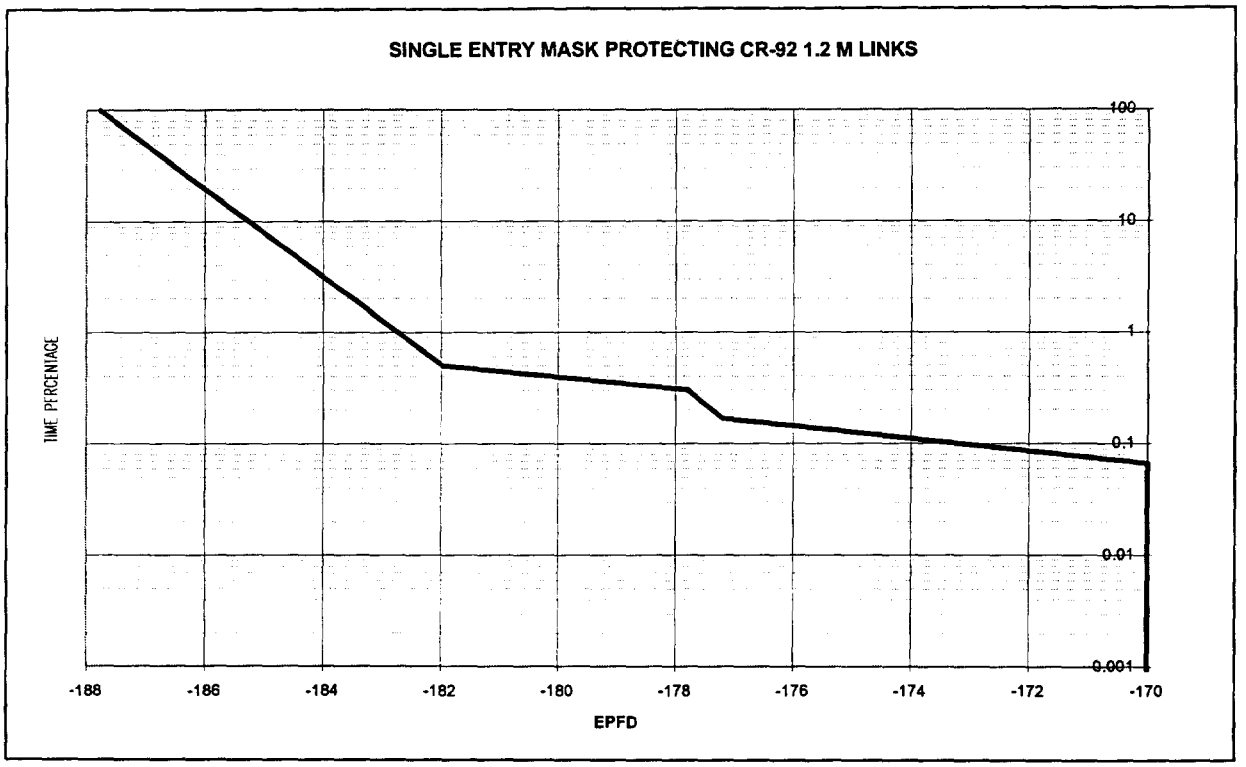
80/ Document 4-9-11/TEMP/65, Addendum 1 and Document 4-9-11/TEMP/55(Rev.1). The JTG has agreed that the EPFD mask shape should accommodate the NGSO interference characteristics. See Document 4-9-11/TEMP/93 (Long Beach).

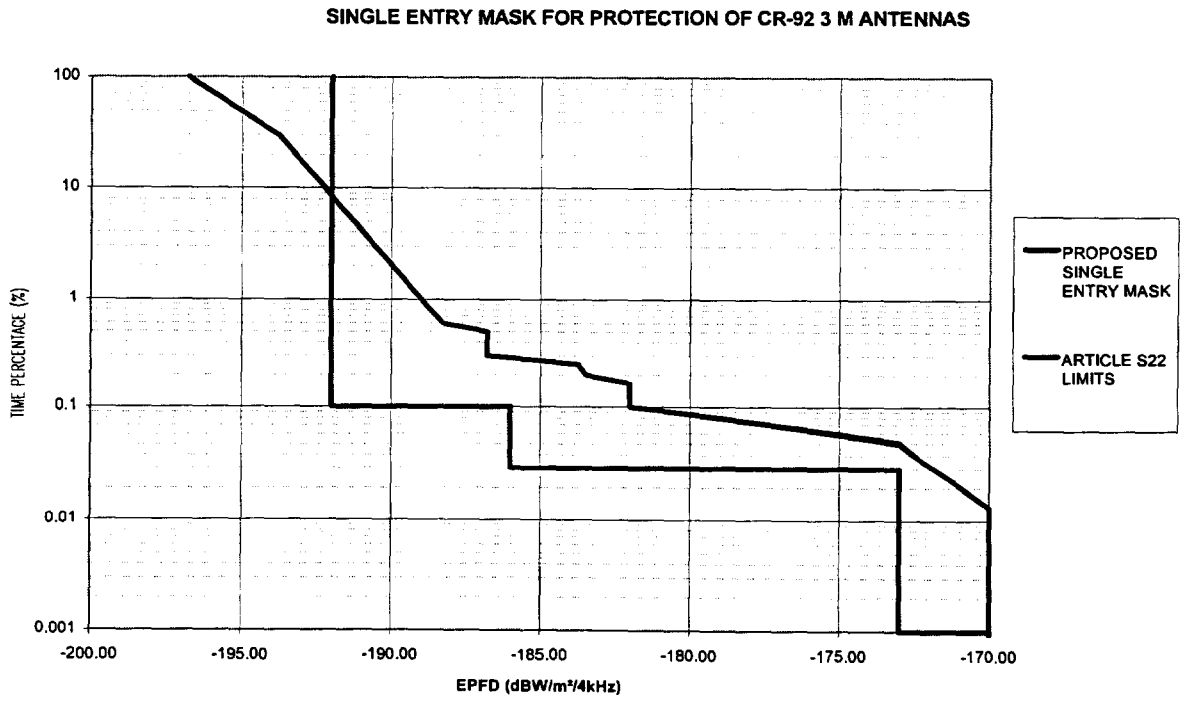
derived, on the basis of a "N" of three. The details of these derivations are contained in Appendix A.

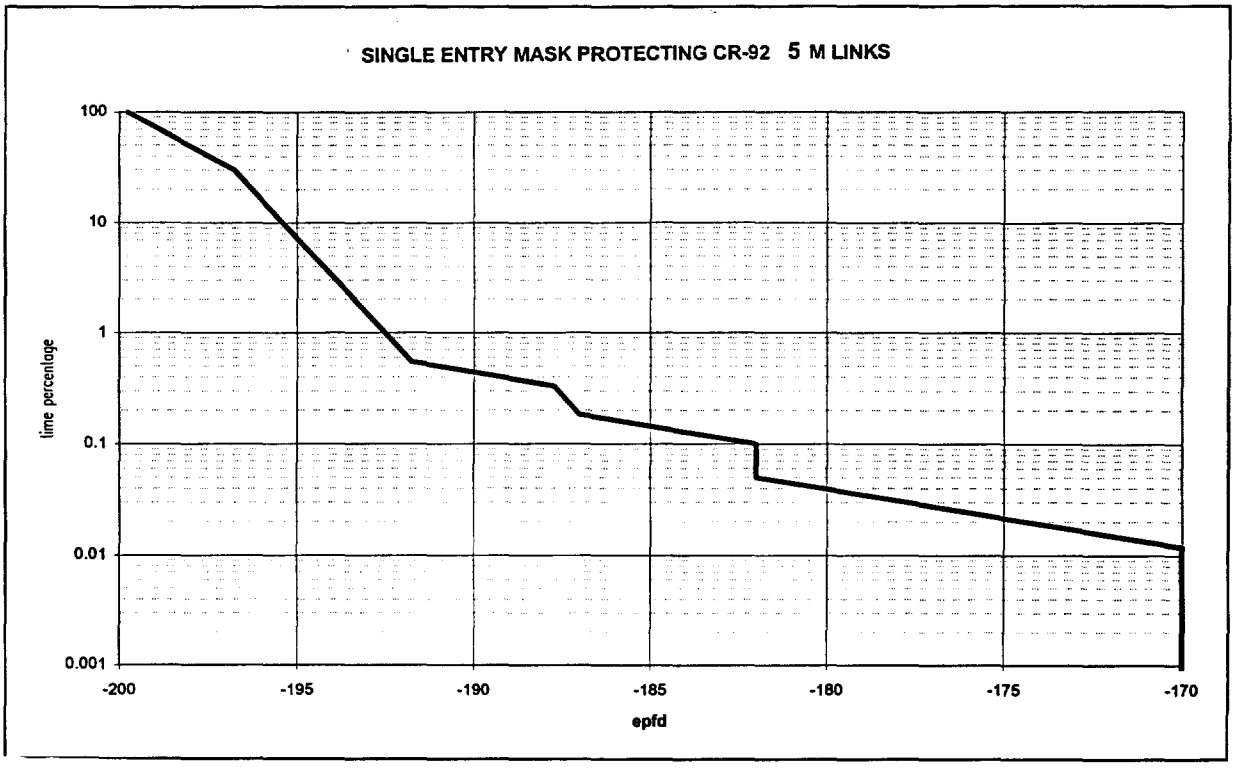
Based on these derivations, SkyBridge proposes the following single entry EPFD masks for 60 cm, 1.2 m, 3 m, 5 m, and 10 m GSO reference antennas:[81/]

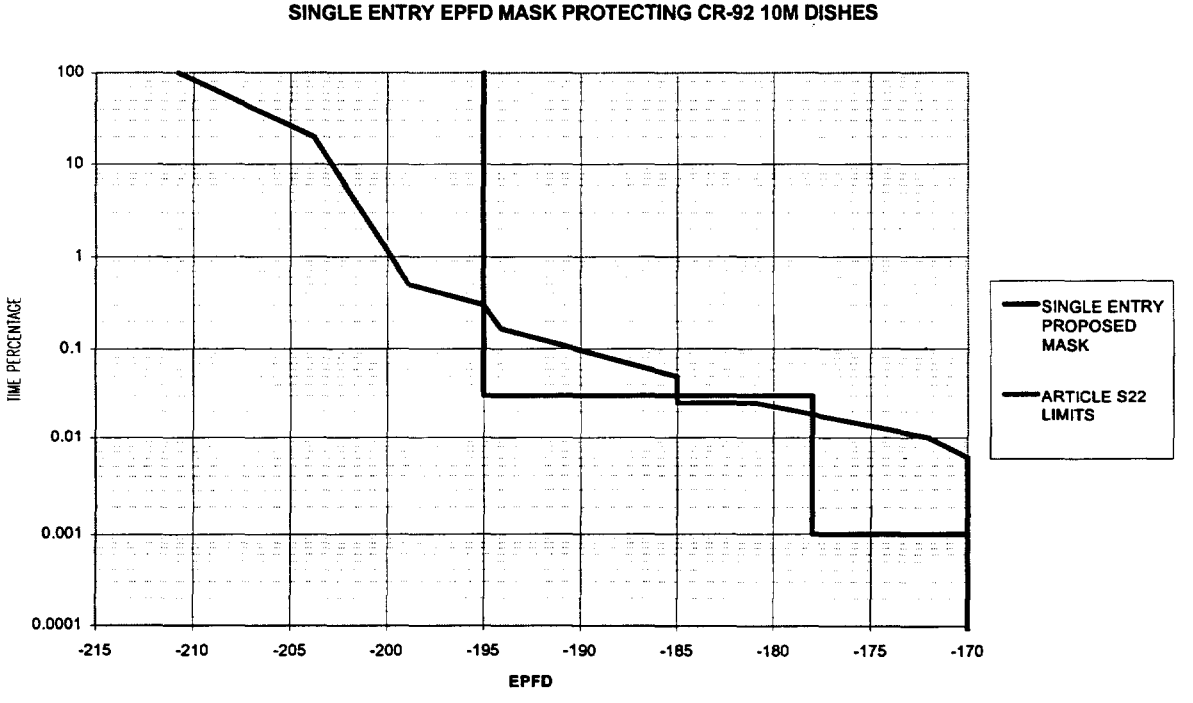


81/ As discussed in Section VII.D.3, infra, the JTG has developed GSO reference antenna patterns to be used in the definition of EPFD. The Commission should correlate SkyBridge's proposed EPFD masks with the reference antenna patterns adopted by the JTG.


SINGLE ENTRY MASK PROTECTING CR-92 1.2 M LINKS
TIME PERCENTAGE
100
10
1
0.1
0.01
0.001
-188
-186
-184
-182
-180
-178
-176
-174
-172
-170
EPFD


SINGLE ENTRY MASK FOR PROTECTION OF CR-92 3 M ANTENNAS
TIME PERCENTAGE (%)
100
10
1
0.1
0.01
0.001
-200.00
-195.00
-190.00
-185.00
-180.00
-175.00
-170.00
EPFD (dBW/m²/4kHz)
PROPOSED SINGLE ENTRY MASK
ARTICLE S22 LIMITS


SINGLE ENTRY MASK PROTECTING CR-92 5 M LINKS
time percentage
100
10
1
0.1
0.01
0.001
-200
-195
-190
-185
-180
-175
-170
epfd


SINGLE ENTRY EPFD MASK PROTECTING CR-92 10M DISHES
TIME PERCENTAGE
100
10
1
0.1
0.01
0.001
0.0001
-215
-210
-205
-200
-195
-190
-185
-180
-175
-170
EPFD
SINGLE ENTRY PROPOSED MASK
ARTICLE S22 LIMITS

It is important to note that these masks have been derived based on the links currently contained in the CR 92 database. As noted above, that database will close on March 15, 1999, and it is anticipated that administrations will file additional sensitive links by that date. Therefore, the derivations contained in Appendix A will be revisited by SkyBridge once all of the relevant links have been provided.

C. Undue Constraints

Resolutions 130 and 538 of WRC-97 both specify that, in adequately protecting GSO FSS systems, the EPFD limits should not cause undue constraints on NGSO FSS systems. In order to achieve this balance, it is necessary to consider the conservative assumptions that are made in the methodologies used to derive the EPFD limits and assess whether a given NGSO system meets the limits. Although SkyBridge believes that the EPFD limits should be primarily dictated by the reasonable protection requirements of existing and designed GSO systems, it is also important to understand the burdens NGSO systems already accept in protecting GSO systems, and the burden to NGSO systems of tightening of the limits.

1. Conservative Assumptions in EPFD Derivation

The criteria and methodologies described above make a number of extremely conservative assumptions, which should be kept in mind when considering sensitive links that appear not to be protected under Recommendation ITU-R S.1323. When the cumulative effect of these assumptions is taken into account, the chance of a link being unprotected in practice is exceedingly remote.

- The EPFD limits have to be met by each NGSO FSS system for any GSO earth station, no matter where in the world it is located, and no matter which direction it is pointed. Studies have shown that not all GSO earth station locations and pointing directions are equally impacted by a given NGSO FSS

system.[82/] Simulations performed for the SkyBridge System show that, for a 60 cm diameter GSO earth station, the maximum EPFD level would be 3 dB lower than the worst-case EPFD level reached over time in 90% of the coverage area,[83/] and 7 dB lower in 50% of the coverage area. As the size of the GSO antenna increases, so do the percentages of the coverage area.[84/] Thus, the vast majority of GSO earth stations will experience far less power than suggested by the short term EPFD limits governing NGSO FSS operation.

- Furthermore, even for a GSO earth station at the worst case location and pointing direction, the maximum power will be experienced only during brief alignments of the NGSO satellite with the GSO satellite and earth station, and then only when the NGSO satellite is actually transmitting at maximum power through its higher sidelobes.

- Even if a particular link does not appear protected under the Rec. ITU-R S.1323 criteria described above, the impact may be mitigated at the system level. This is because, due to the geographic distribution of the worst case interference levels produced by NGSO FSS systems, the geographic area within which a link might be sensitive will be only a few tens of kilometers in diameter. Furthermore, typical coverage areas of GSO FSS space stations in the Ku-band suggest that these areas, when they cover very low rainfall rate regions, also often encompass high rainfall rate regions as well. Therefore, in most cases, either extra power will already be available toward the worst-case earth stations, or power balancing may be possible to balance power between earth stations.[85/]

- In practice, an NGSO FSS system will not be able to generate exactly the same EPFD statistics as those defined by EPFD mask. Rather, some part or parts of the EPFD mask will act to bound the operation of the system. For

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82/ SkyBridge has consistently presented simulations results for the SkyBridge System for the worst-case configuration. The EPFD statistics presented in the 1999 Amendment were computed for the worst-case configuration (for the SkyBridge System) of a GSO earth station located at 42.5 N latitude and 53.5 E longitude pointing toward a GSO satellite at 81 E. (This location depends on the actual traffic and switching strategy modeled, and is therefore subject to change.)

83/ The coverage area is defined as a 40° latitude by 40° longitude zone around the worst-case location.

84/ See Document 4-9-11/268 and Addendum 1.

85/ See Document 4-9-11/272 and Addendum 1.

other percentages of time, the EPFD generated by the system can be much less than the limits.

- The Rec. ITU-R S.1323 methodologies reduce the number of fading sources that affect the GSO link. In fact, only rain attenuation is considered. Sun outages, sand storms, equipment breakdown, depolarization effects, satellite pointing accuracy, etc., have not been taken into account. Such assumptions lead to a perceived improvement in the GSO link performance, that does not exist in reality.[86/] As a result, NGSO FSS systems will contribute far less than 10% of the actual unavailability time of a GSO system, as permitted under Rec. ITU-R S.1323, when these other sources of outage are taken into account. This is especially the case for very sensitive theoretical links in low rain zones.[87/]

- As described in Section VII.D below, the software validation tool to assess compliance of an NGSO FSS system will by definition provide an upper bound of the actual interference caused by the system, as it assumes worst-case configurations for all satellites at the same time. In addition, the GSO earth station antenna pattern used in the simulations remains a conservative envelope, leading to a pessimistic estimate of the power received from NGSO FSS systems.

For all of these reasons, the studies on EPFD limits necessarily over-estimate, by a significant margin, the impact of any given NGSO FSS system on GSO systems. This phenomenon must be taken into account in establishing the relevant limits, so as not to impose an undue/unnecessary burden on either GSO or NGSO systems.

2. Design Features of NGSO Systems to Protect GSO Systems

Although NGSO system architecture varies, all NGSO FSS systems intended to co-exist with GSO systems incorporate design features to protect GSO arc

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86/ See Document 4-9-11/267.

87/ In such cases, the rain fade is of second order. All other availability degradations will substantially reduce the actual availability.

operations. These features significantly increase the cost and complexity of such NGSO FSS systems.

In the case of SkyBridge, the following burdens have been accepted for the protection of GSO systems:[88/]

- GSO arc avoidance is employed, which increases the number of satellites required for global coverage.
- A spread spectrum waveform and power control are used to reduce the power required for a given link. Even so, under the WRC-97 provisional limits, for example, SkyBridge would be required to use power 5 dB below that originally envisioned for the system, with a consequent reduction of system capacity.
- The satellite antennas have been optimized to meet the burden imposed by 100% EPFD limits, which directly limits the PFD that can be transmitted by the sidelobes of the antenna. The earth station antennas have been carefully designed to meet tight antenna patterns, in all cases below the Recommendation ITU-R S.465 envelope.

3. Impact on NGSO Systems of a Tightening of the Limits

As discussed above, because the juxtaposition of NGSO systems in relation to GSO systems is time-varying, in the general case it is necessary to consider both the long term (or usual) situation, and short term events.

In the case of short term limits, for a SkyBridge-like constellation, the maximum levels of downlink interference occur during an NGSO sidelobe into GSO main beam alignment.[89/] A tightening of the short term limits would require a

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88/ See Document 4-9-11/266.

89/ It has been noted that some systems do not produce short term events in the same way as a SkyBridge-like system. (The worst-case interference levels for such systems occur when the mainlobe of the NGSO satellite is transmitting into the GSO sidelobes.) See Document 4-9-11/TEMP/67 (Long Beach). While it is possible for much higher altitude NGSOs, such as some MEOs and

(continued...)

corresponding reduction in the NGSO sidelobe PFD. This would require a tightening of the NGSO antenna pattern, or a decrease in the EIRP. Both design modifications would have serious impacts on the system cost and complexity. In general, a tightening of the NGSO satellite antenna pattern would require increasing the antenna aperture size, which would lead to significant increases in the volume, the complexity, and the mass of the antenna, and thus of the satellites.[90] An EIRP reduction accomplished by decreasing the carrier power level will reduce NGSO system margin, affecting availability, or, to maintain availability objectives, causing a dB-for-dB reduction in the system capacity.[91] In the case of SkyBridge, for example, a 1 dB decrease in power results in a decrease by 4 codes of the carrier capacity,

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89/ (...continued)
QGSOs, to avoid sidelobe transmissions to GSO mainlobes as satellites traverse the GSO arc, this is not possible for LEO systems that maintain global coverage. However, a key advantage of LEO systems -- true real-time, two-way connectivity -- is impeded with those higher-altitude systems due to their longer latency times, a fact recognized by the Commission as significant regarding the ability of certain satellite systems to provide various statutorily mandated services. See e.g., Section 706 Order at 28, nn.110-111.

90/ As described in greater detail in Document 4-9-11/266, use of a larger antenna size would decrease the number of beams that can be generated by the satellite, thus reducing system capacity, and increase the number of radiating elements and controllable devices per antenna. It could also increase the necessary launcher fairing envelope, decreasing the number of satellites that may be launched at any given time. Decreased inter-element spacing would also lead to an increase in RF insertion loss, and reduced frequency bandwidth. Tighter design accuracy and manufacturing tolerances would adversely impact the cost and schedule of NGSO design, and impose additional risk on the project.

91/ Document 4-9-11/TEMP/56 (Long Beach).

which corresponds to a 20% reduction of the system capacity.[92] An EIRP reduction could also be accomplished by decreasing the spectral density by modifying the NGSO waveform. A 1 dB tightening of the EPFD limits would require an increase in the carrier bandwidth by 1.26 to maintain a constant EIRP. Even if feasible, the chip rates are already high for interactive broadband commercial applications, and the increase would lead to a poorer bit rate-per-Hz ratio and a consequent reduction in capacity.[93]

With respect to limits governing the long term situation, the issue is similar. Tightening of the limits would require either decreases in the satellite PFDs, or further avoidance of NGSO main beam to GSO sidelobe configurations. The former would lead to the capacity reductions noted above. The latter would require an increase in the size of the GSO arc exclusion zone, which would increase the number of satellites required, and greatly complicate resource allocation in the NGSO network.

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[92] See Document 4-9-11/266. To keep the same capacity with a lower EIRP, the NGSO could increase the earth station antenna size. This would significantly increase cost and complexity for NGSO FSS systems which necessarily employ paired tracking beams and which must meet tight size and cost restrictions for mass-produced user terminal earth stations.

[93] Finally, the effects of a tightening of the EPFD limits could be offset by decreasing the percentage of time that the NGSO system generates a given EPFD level. This would require a decrease in the altitude of the satellites (so they fly through the GSO main lobes faster), which would increase the number of satellites needed to ensure global service. Furthermore, this technique would not help meet the 100% limits.

4. Parametric Study of Effect of Current Limits on GSO FSS

Whenever two services are asked to share a frequency band, some constraints are imposed on each side in order to make this sharing possible. In the case of the new Ku-band NGSO FSS service, some degree of burden sharing will be necessary for GSO systems if the benefits of NGSO FSS service are to be realized. Such an obligation is unavoidable in any sharing scheme that seeks to maximize the efficient use of scarce radiofrequency spectrum. The limits proposed by SkyBridge in the previous section ensure that this burden is kept to an extraordinarily minimal level. In fact, when compared with previous sharing schemes adopted by the Commission, such as 2° orbital separation (for C-band and Ku-band GSO FSS), minimum antenna size (for Ka-band GSO FSS), and even relocation (for 2 GHz FSS), the burden asked of the GSO FSS community to allow sharing with NGSO FSS in this band is truly negligible.

The limits proposed by SkyBridge will allow the overwhelming majority of GSO services, now and in the future, to continue growing and evolving unencumbered by NGSO FSS. This claim is supported by studies carried out by the GSO community themselves and submitted as part of the record in this docket.[94/] As can be seen by a document prepared by PanAmSat for the recent Long Beach JTG[95/] meeting, which analyzes the adequacy of the provisional limits adopted at WRC-97, only under the most extreme circumstances would the WRC-97 limits have an impact

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94/ Letter from Joseph A. Godles, attorney for PanAmSat Corporation, dated January 8, 1999, submitting the contents of Document 4-9-11/342 into Docket No. 98-206.

95/ Document 4-9-11/342.